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PATENT SPECIFICATION

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(54) BALLS

(71) We, MONSANTO COMPANY, a corporation organised under the laws of the State of Delaware, United States of America, of 800 North Lindbergh Boulevard, St. Louis, Missouri 63166, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to balls, and particularly to balls covered with a fabric, for example tennis balls.

Tennis ball fabrics of various kinds have been proposed in the past. Many represent attempts to substitute less expensive material (e.g. synthetic polymers) for the wool heretofore commonly used and/or to avoid the need for a woven ball cover fabric. For example, it has been proposed to simulate the loft, feel and in-play performance of wool while retaining most of the strength of fabric woven from spun yarn; there have been developed fabrics produced by needling a batt or batts of synthetic and/or regenerated staple fibers onto a flexible backing material which may be woven, knitted or nonwoven.

In accordance with the present invention, there is provided a ball comprising a resilient spherical member and a nonwoven fabric adhering to and substantially covering the outer surface of the spherical member, the fabric having been prepared from continuous synthetic polymer filaments not substantially aligned in the plane of the fabric.

A preferred fabric is that described in our British Patent Application No. 39538/77.

This invention relates principally to tennis balls but also to other kinds of balls advantageously having a nonwoven fabric surface, e.g. other playballs smaller or larger than tennis balls and on which the fabric surface may affect aerodynamic, rebounding or other performance characteristics of the ball. Additionally or alternatively, the nonwoven fabric surface may serve some other purpose such as, e.g., retention of the ball on a receiving surface such as that of a Velcro-covered target. Thus the resilient spherical member to which the nonwoven fabric is attached may be hollow or solid, heavier or lighter than that of a conventional tennis ball and composed of rubber, plastics, a solidified foam or other desired material. The ball is substantially, even more typically predominantly and, in the case of a tennis ball, substantially completely covered by the nonwoven fabric employed in this invention. That is, in the case of a tennis ball the nonwoven fabric covers essentially all of the outer surface of the ball except for that portion occupied by the single narrow continuous seam between the two dumbbell-shaped portions of the fabric used in covering of the ball. In production of such balls, the fabric may be adhered to the resilient spherical member by any suitable substance, e.g. a thermosettable composition such as vulcanizable rubber cement of the type typically used in tennis ball production or a thermoplastic cement such as a polyvinyl alcohol, or by any suitable mechanical technique such as stitching or needling.

The term nonwoven fabric as used herein is intended to mean a planar assembly of textile fibers held together by mechanical interlocking in a random web or mat, and/or by bonding which may take place as a result of separately melt-spun filaments fusing together at a site of deposition (e.g. on a moving conveyor) or by calendering optionally carried out with the application of heat (e.g. as described in U.S. Patent 3,853,651 issued 10 December 1974 to P. Porte) or by autogenous bonding effected with use of an activating substance such as steam or, in the case of polyamide filaments, a hydrogen halide (e.g. as described in U.S. Patent 3,516,900 issued 23 June 1970 to W. C. Mallonee et al) or by application of a chemical bonding agent (e.g. a self-reactive acrylic copolymer or other curable polymeric composition) or by a combination of two or more of these techniques.

In some preferred embodiments in which the fabric is held together at least in part

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by mechanical interlocking of fibers, such interlocking is effected by needle-punching which intermingles filaments in the fabric and increases inter-filament friction within the fabric. Such needle-punching may be carried out by various known techniques, e.g. as described in U.S. Patents 2,908,064 issued 13 October 1959 to H. G. Lauterbach et al and 2,958,113 issued 1 November 1960 to H. G. Lauterbach. Needle-punching of a nonwoven fabric consisting essentially of continuous synthetic polymer filaments is also described in the aforementioned U.S. Patent 3,853,651. The fabric used in this invention may have been needle-punched with any needling density sufficient to provide the desired degree of fabric cohesiveness enhancement, but in general such a needling density is between about 50 and about 1,000 penetrations per square centimeter (cm^2) of the area of one side of the fabric. With fabrics of the weights generally used on tennis balls such needle-punching is typically carried out with a needling density of at least about 100 and preferably at least about 200 penetrations per cm^2 of such area. This needle-punching may be carried out entirely from one side of the fabric or partly from each side thereof.

The fabric used in the present invention is one that has been prepared from continuous filaments which, for purposes of this invention, are distinguished from fiber of staple length and from yarn spun from staple fiber, and hence have an average filament length substantially greater than those generally associated with staple fiber. It may have an average filament length on the order of that characteristic of continuous filaments, but in many embodiments it may have an average filament length substantially shorter than that, e.g. as a result of fabric processing such as napping, buffing, brushing or the aforementioned needle-punching which may cut or break some continuous filaments employed in construction of the fabric. Moreover, the phrase "having been prepared from continuous filaments" as used herein should be considered not necessarily contrary to the inclusion of a minor proportion (e.g. up to about 25%) of at least one non-fibrous substance (e.g. a resinous material or bonding agent) which does not alter the nature of the fabric so as to prevent substantial realization of the advantages of this invention, particularly as described herein.

As aforesaid, such continuous filaments are composed of at least one synthetic polymer which may be a filament-forming polyester (e.g. polyethylene terephthalate), polyamide such as nylon 66 or nylon 6, polyolefin such as polyethylene or polypropylene, polyurethane or other man-made polymeric composition that can be spun in the form of continuous filaments. The filaments may be homogeneously composed of one of such polymers, or they may be spun from a blend of two or more of such polymers, or they may be conjugate (e.g. side-by-side or sheath-core) filaments of a plurality of such polymers. Otherwise, the fabric used in this invention may have been prepared from continuous filaments of one of such polymers intermingled with continuous filaments of another of such polymers, or of at least one layer of continuous filaments of one such polymer associated (e.g. by lamination or needling) with one or more layers of continuous filaments of another of such polymers. For good fabric wear resistance, strength and modulus, it is preferred to use a polyester or a polyamide such as nylon 66. Particularly for use in tennis balls and other outdoor playballs in which substantial moisture pick-up by the fabric is undesirable, it is especially preferred that the continuous filaments be predominantly or, usually more preferably, substantially completely composed of relatively hydropathic polymer such as a polyester (e.g. polyethylene terephthalate).

Also, as aforesaid, the invention utilizes fabric in which such continuous filaments are not substantially aligned in the plane of the fabric, it being understood that said plane has the contour of the surface of a sphere when the fabric is conformed to the spherical member of the ball of this invention and that the degree of filament alignment, if any, in the plans of the fabric may be observed or measured while the fabric is conformed to that sphere or, often more conveniently, with the fabric arranged on a flat surface either before being conformed to the spherical member or after being removed therefrom. In many embodiments the fabric has been produced by a process in which there is a direction of fabric movement, i.e., the machine direction (M.D.) of the fabric, and a transverse direction (T.D.) which is that of its width dimension perpendicular to both the M.D. and the thickness dimension of the fabric. Thus it will be apparent that the continuous filaments in such a fabric employed in this invention are not substantially aligned in a plane defined by the M.D. and T.D. of the fabric. As such, the continuous filaments in the fabric employed in this invention are not substantially aligned in the M.D. of that fabric and, consequently, that fabric is not anisotropic in the manner characteristic of fabrics composed of such substantially aligned fibers.

In some embodiments of this invention the filaments in the fabric are not substantially aligned, but in many embodiments those filaments or portions thereof are substantially aligned in a direction essentially perpendicular to the plane of the fabric, e.g. as a result of needling, napping or other mechanical processing of the fabric. Typically in the fabric employed in this invention, the filament directionality components which lie within the

plane of the fabric are generally randomly disposed within that plane. This is normally coincident with a high degree of fabric uniformity in the plane of the fabric, as evidenced by properties which are very similar in the M.D. and T.D. of the fabric. To illustrate, in many embodiments of the fabric used in this invention, the ratio of the tensile strength of the fabric in the M.D. to the tensile strength of the fabric in the T.D. is between about 0.8 and about 1.2, more typically between about 0.9 and about 1.1, and most typically between about 0.95 and about 1.05. There are various known processes for producing nonwoven fabrics of those kinds, e.g. as described in the aforementioned U.S. Patents 3,516,900 and 3,853,651.

Although fabric of various weights may be used in this invention, such weights are generally between about 100 and about 1,000 g/m^2 of gross fabric area, exclusive of the weight of any adhesive applied to the fabric for purposes of adhering same to the spherical member of the ball. In general the fabric weight is at least about 200 g/m^2 and, most typically for use in tennis ball production, at least about 400 g/m^2. The fabric may be as thick or thin as desired but in most instances it has an average thickness between about 1 and about 10 mm and, in production of balls having a cover fabric most similar to that of conventional tennis balls, generally between about 1 and about 5 mm. There are no specific limits on the denier of the filaments employed, but the average denier per filament is generally between about 1 and about 20, typically between about 2 and about 15 and, for use in tennis ball production, usually between about 3 and about 10. Mixtures of filaments of different deniers may be advantageous in some cases.

In some embodiments, the ball may be covered with a fabric essentially as produced by one of the known processes for production of a generally randomly disposed continuous filament fabric, e.g. the process described in the aforementioned U.S. Patent 3,853,651. In other embodiments it may be desirable to modify such a fabric to more closely simulate a conventional tennis ball fabric. For example, a surface of the fabric may be raised, e.g. by tumbling the fabric-covered ball against wire brushes or suitable abrading material or, alternatively before adhering of the fabric to the ball, by napping of the fabric. Such napping can be effected by use of a conventional napping machine, e.g. one of the single or double acting or knit goods napping machine of types well known in the art. Thereafter it is usually preferable to shear the resulting nap to a desired (typically uniform) fabric thickness. This may likewise be carried out with equipment known in the art. For a description of such napping and shearing procedures and equipment, see American Wool Handbook, Von Bergen and Mauersberger, Textile Book Publishers, Inc., New York, N.Y., 2nd Ed., pp. 841—59 (1948).

Due to the high proportion of continuous filaments in the fabrics used in accordance with this invention, balls covered with those fabrics exhibit good in-play properties of durability and wear resistance. Because those filaments are not substanially aligned in the plane of the fabric, the properties of the fabric are essentially uniform in all directions parallel to that plane and hence over all of the surface of a ball covered with such fabric. This uniformity of the fabric as evidenced by, e.g., the substantial equality of tensile strengths and elongations in the machine and transverse directions of the fabric, is advantageous in avoiding the need for bias cutting of ball cover shapes and the lower fabric yields which normally accompany such bias cutting. In addition, production of balls within the scope of this invention has the advantage that it can be carried out with fabric made by a simple, low-cost procedure from a single, relatively inexpensive polymeric and/or filamentary raw material. In particular, production of such balls can be carried out with fabric made from filaments essentially devoid of crimp, i.e., filaments having no substantial potential for greater intermingling as a result of relaxation after laydown in formation of such fabric.

These and other advantages will be apparent from the following specific examples which are illustrative only and do not imply any limitations on the scope of the invention. In these examples, fabric tensile strengths and elongations are measured in accordance with ASTM Test Method D 1682—64 using a 5-cm wide fabric sample.

EXAMPLE 1.

Essentially as described in U.S. Patent 3,853,631, a nonwoven fabric is prepared from continuous polyethylene terephthalate (PET) filaments by extruding such filaments, drawing them to a denier per filament (dpf) of 9, depositing them on a moving conveyor in a generally random arrangement and then needle-punching the deposited filaments with a needling density of 500 penetrations per cm^2 of the resulting fabric. That fabric weighing 806 g/m^2 and having a uniform thickness of 3.1 mm and an average density of 0.26 g/cc is uniformly sprayed on one side with enough of a 25%-solids aqueous dispersion of a self-reactive acrylic copolymer latex bonding agent (backbone composition—butyl acrylate/ethyl acrylate; polymer T_g of $-30°C$) to deposit thereon 40 g/m^2 of the bonding agent which is then dried and cured at 150°C. The other side of the fabric is thereafter napped using a conventional 90-inch 24-rool knit goods napping machine described

in the brochure "Hi-Torc Napping or Raising Machines" published in 1965 by the David Gessner Co., Worcester, Massachusetts. The napping is carried out with 3 passes through the machine set at an energy level of 500 pounds, resulting in a nap composed of the raised ends of filaments broken by the action of the napping machine. Using a conventional shearing machine described in the brochure "Cloth Shearing Machine, Type CA3c" published in 1956 by Franz Muller Maschinenfabric, M. Gladbach (Rheinland), West Germany, the nap is sheared to a uniform fabric thickness of 3.4 mm which includes a nap having a uniform thickness of 0.5 mm and an average density of 0.05 g/cc. The fabric thereby produced weighs 820 g/m² and is soft and pleasing to the touch. The filaments in the fabric are not substantially aligned in the plane of the fabric, and the fabric is very highly uniform in that plane, as shown by the following properties:

	M.D.	T.D.	M.D.:T.D.
Tensile Strength, kg/cm	45.1	44.7	1.01
Elongation, %	63	64	0.98

Three coatings of a vulcanizable rubber cement are applied to the unnapped side of the fabric which is then cut into the dumbbell shapes conventionally used in preperation of tennis ball covers. The edges of the shapes are coated with the same cement after which two of the coated shapes are placed on and conformed to a hollow rubber sphere of the type normally used in tennis ball production. This assembly is placed in a conventional tennis ball mold and heated at 135°C for 20 minutes to vulcanize the two pieces of cover fabric to the sphere. After the ball is removed from the mold, allowed to cool to ambient temperature and brushed lightly, its appearance, tactile qualities, performance in play and wear rate are essentially like that of a conventional tennis ball having a woven wool or wool/nylon fabric cover.

EXAMPLE 2.

When there is carried out a procedure essentially like Example 1 except that the fabric is produced with continuous nylon 66 (polyhexamethylene adipamide) filaments rather than PET filaments, the average densities of the resulting fabric and its nap are 17—18% below those of the fabric produced in Example 1, the tensile strengths and elongations of the resulting fabric are 44 kg/cm and 68% (M.D.) and 43 kg/cm and 69% (T.D.), respectively, the M.D.:T.D. ratios of those tensile strengths and elongations are 1.02 and 0.99, respectively, and the properties, appearance, performance and overall suitability of tennis balls covered with the fabric are very similar to those of the ball produced in Example 1.

EXAMPLES 3 & 4.

When there is carried out a procedure essentially like Example 1 except that in one instance, a styrene-butadiene rubber latex and, in a second instance, a caprolactone polyester cross-linked with an aminoplast is substituted for the acrylic bonding agent, the properties, appearance, performance and overall suitability of tennis balls covered with the resulting fabric are essentially the same as those of the ball produced in Example 1.

EXAMPLE 5.

When there is carried out a procedure essentially like Example 1 except that the fabric before napping weighs 468 g/m² and has a uniform thickness of 1.8 mm, the M.D. and T.D. tensile strengths of the napped and sheared fabric are each about 40% lower than the corresponding property of the fabric produced in Example 1, the M.D.:T.D. ratios of those tensile strengths and elongations are essentially the same as in Example 1, and the appearance, performance, durability and overall suitability of tennis balls covered with the resulting fabric are essentially the same as those of the ball produced in Example 1.

EXAMPLE 6.

A nonwoven fabric is prepared from continuous PET filaments generally randomly disposed in the plane of that fabric and having a dpf of 1 and needle-punched with a needling density of 1,000 penetrations per cm² using a quantity of filaments such that the resulting fabric weighs 150 g/m² and has a uniform thickness of 1.0 mm and an average density of 0.15 g/cc. This fabric is uniformly sprayed on one side with enough of the bonding agent dispersion used in Example 1 to deposit thereon 5 g/m² of that bonding agent which is then dried and cured at 150°C. The other side of the fabric is thereafter napped using the napping machine employed in Example 1. The napping is carried out with 3 passes through the machine set at an energy level of 300 pounds, resulting in a nap composed of the raised ends of filaments broken by the action of the napping machine. Using the shearing machine employed in Example 1, the nap is sheared to a uniform fabric thickness of 1.4 mm which includes a nap having a uniform thickness of 0.5 mm and an average density of 0.01 g/cc. The fabric thereby produced weighs 145 g/m², the filaments therein are not substantially aligned in the plane of the fabric, and the fabric is highly uniform in that plane, as shown by the following properties:

	M.D.	T.D.	M.D.:T.D.
Tensile Strength, kg/cm	4.7	4.5	1.05
Elongation, %	58.7	64.7	0.91

This fabric is lighter than those most commonly used on tennis balls, but the appearance and durability of balls covered with this fabric are otherwise similar to those of the ball produced in Example 1.

EXAMPLE 7.

A nonwoven fabric is prepared from continuous PET filaments generally randomly disposed in the plane of that fabric and needle-punched essentially as in Example 1 but with a dpf of 20, a needling density of 100 penetrations per cm² and a quantity of filaments such that the resulting fabric weighs 960 g/m² and has an average density of 0.2 g/cc. This fabric is calendered to a uniform thicknees of 2.4 mm and an average density of 0.4 g/cc and then uniformly sprayed on one side with enough of the bonding agent dispersion used in Example 1 to deposit thereon 75 g/m² of that bonding agent. The bonding agent is dried and cured at 150°C and the other side of the fabric is then napped using the napping machine employed in Example 1. The napping is carried out with 6 passes through the machine set at an energy level of 600 pounds, resulting in a nap composed of the raised ends of filaments broken by the action of the napping machine. Using the shearing machine employed in Example 1, the nap is sheared to a uniform fabric thickness of 6 mm which includes a nap having a uniform thickness of 3.9 mm and an average density of 0.02 g/cc. The fabric thereby produced weighs 993 g/m², the filaments therein are not substantially aligned in the plane of the fabric, and the fabric is highly uniform in that plane, as shown by the following properties:

	M.D.	T.D.	M.D.:T.D.
Tensile Strength, kg/cm	45.4	42.0	1.08
Elongation, %	69	67	1.03

This fabric is heavier than those most commonly used on tennis balls, but the appearance and durability of balls covered with this fabric are otherwise similar to those of the ball produced in Example 1.

WHAT WE CLAIM IS:—

1. A ball comprising a resilient spherical member and a nonwoven fabric adhering to and substantially covering the outer surface of the spherical member, the fabric having been prepared from continuous synthetic polymer filaments not substantially aligned in the plane of the fabric.

2. A ball according to Claim 1, the fabric being needle-punched with a needling density between 50 and 1,000 penetrations per cm² and weighing between 100 and 1,000 g/m².

3. A ball according to either Claim 1 or Claim 2, the filaments having an average denier per filament between 1 and 20, and the fabric having an average thickness between 1 and 10 mm and a machine direction:transverse direction ratio of tensile strengths between 0.8 and 1.2.

4. A ball according to Claim 1 that is a tennis ball.

5. A tennis ball according to Claim 4, the fabric being needle-punched with a needling density between 100 and 1,000 penetrations per cm².

6. A tennis ball according to Claim 5, the fabric weighing between 200 and 1,000 g/m² and having an average thickness between 1 and 5 mm.

7. A tennis ball according to Claim 6, the filaments having an average denier per filament between 1 and 20, the fabric weighing at least 400 g/m² and the needling density being at least 200 penetrations per cm².

8. A tennis ball according to Claim 7, the fabric having a machine direction:transverse direction ratio of tensile strengths between 0.8 and 1.2.

9. A tennis ball according to Claim 8, the said ratio being between 0.9 and 1.1.

10. A tennis ball according to Claim 8, the said polymer comprising polyester.

11. A ball according to Claim 1 substantially as described in any of the Examples.

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